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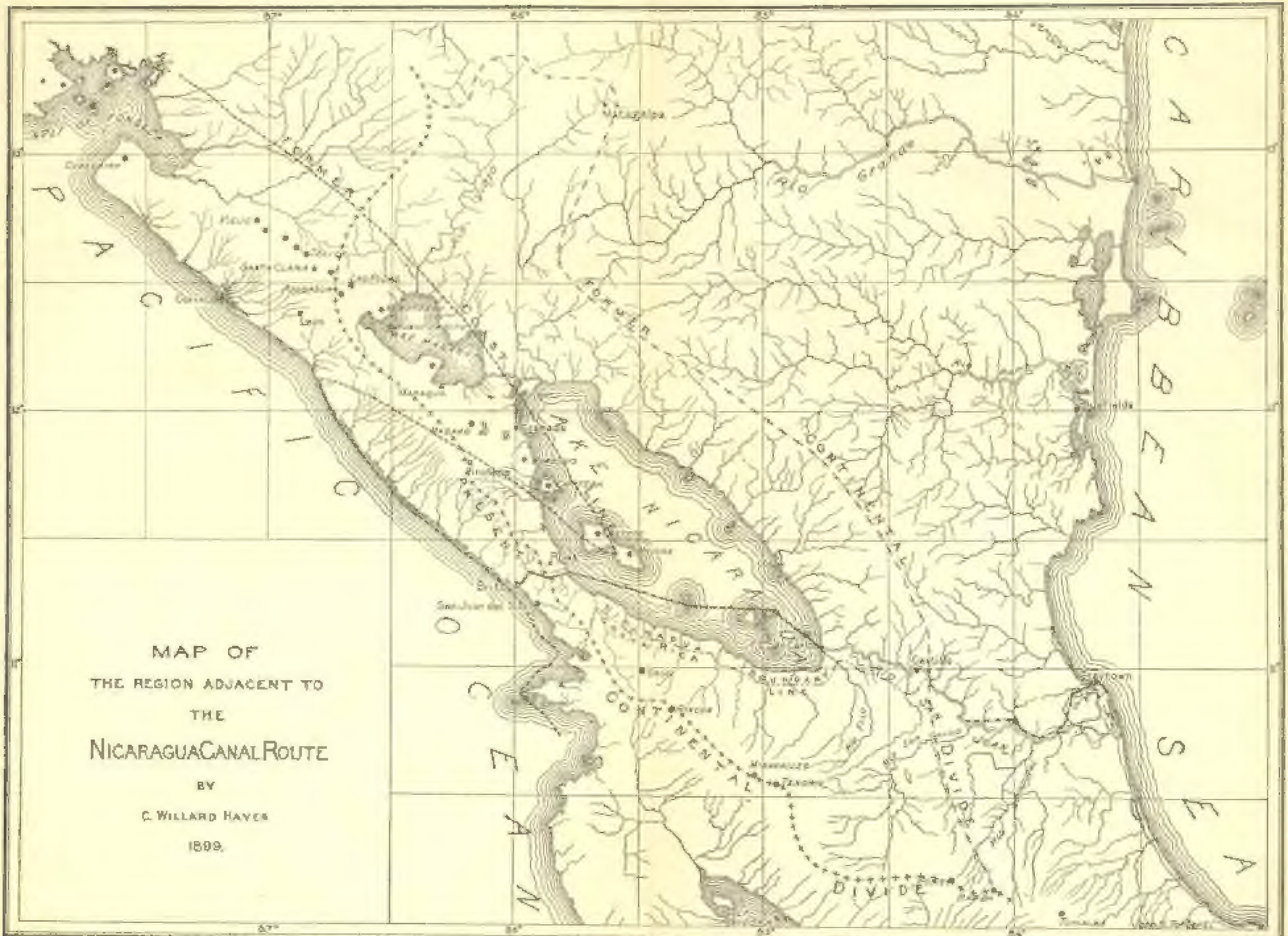
MAP OF
THE REGION ADJACENT TO
THE
NICARAGUA CANAL ROUTE
BY
C. WILLARD HAYES
1899.
CARIBBEAN SEA
PACIFIC OCEAN
LAKE NICARAGUA
FORMER CONTINENTAL DIVIDE
CONTINENTAL DIVIDE
Rio Grande
Matagalpa
Castillo
Greytown

THE
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Vol. X JULY, 1899 No. 7

PHYSIOGRAPHY OF THE NICARAGUA CANAL ROUTE

By C. Willard Hayes,
United States Geological Survey

The region whose topography and geology have a most intimate bearing upon the problems connected with the proposed Nicaragua canal embraces northern Costa Rica and southern Nicaragua. It is sharply limited on the south by the high volcanic range of Costa Rica, which rears its massive form diagonally across the isthmus. It is limited to the north somewhat less definitely by the increasing height of a deeply dissected plateau, which merges with the mountains of northern Nicaragua. Between these limits lies a broad irregular depression, which extends very nearly across the isthmus in a diagonal direction parallel with the Costa Rican range. This depression is now occupied chiefly by Atlantic drainage, the continental divide lying within a short distance of the Pacific. It contains the basins of Lakes Nicaragua and Managua and their outlet, the San Juan river. It is important to note that the Nicaraguan depression is not a simple river valley. The portion with which we are chiefly concerned, that lying between the lake and the Caribbean, embraces two distinct drainage basins, whose streams formerly flowed in opposite directions, although by a geologically recent reversal of the drainage they now have a single outlet to the sea.

When examined in detail the surface of the Nicaraguan depression presents considerable relief, and its topographic features naturally group themselves into three classes.

Extending from the base of the Costa Rican volcanoes northward to the San Juan river and beyond are many hills whose

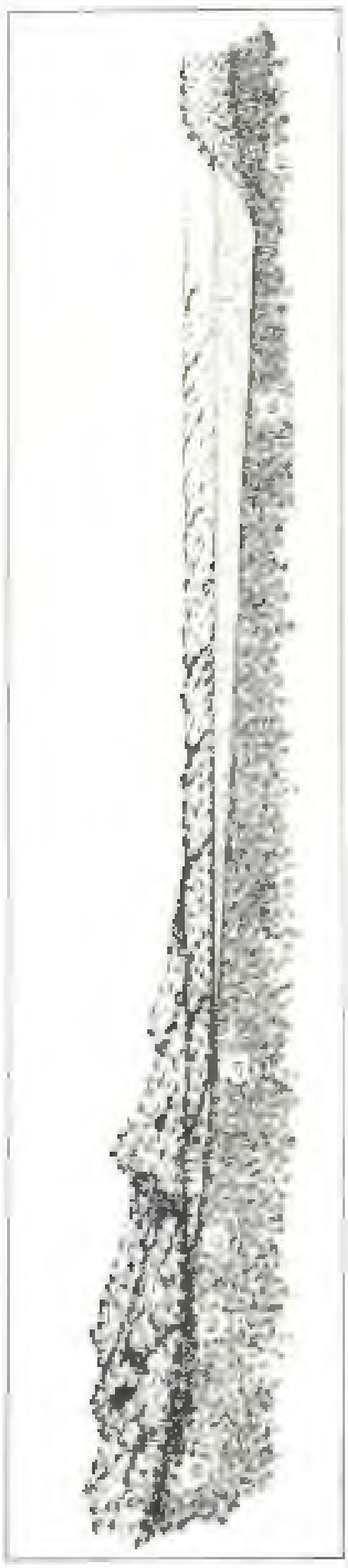
summits reach a tolerably uniform elevation on north and south lines, but increase in height from either side of the isthmus toward its axis. In the vicinity of the San Juan these hills have steep slopes and rounded summits. Some distance back from the San Juan the valleys which separate them are narrower, and there are considerable areas of level or undulating surface at an altitude corresponding with the summits of the hills nearer the center of the depression. It is evident that if the valleys were filled even with the summits of these hills, there would be formed a broad undulating plain, sloping gradually up from either side toward the axis of the isthmus. It is entirely probable that such a plain once existed, and that it has been converted into a series of even-topped hills and ridges by the subsequent cutting of stream channels below its surface. The manner in which this plain was originally formed is manifestly by the long-continued action of streams when the land stood considerably lower than now—that is, by the process of stream degradation or baseleveling. It was therefore a gradational, not a constructional, plain. If it were reconstructed by the filling of the stream valleys, its present altitude would vary between 100 and 200 feet.

As indicated above, numerous valleys now intersect the surface of this old plain. Except in the case of the San Juan they vary with the size of the stream which they carry. The reasons for this exception will be pointed out later. The valleys are broad in proportion to the extent to which the old plain has been destroyed, and they grow narrower with increasing distance from the axis of the depression. The smaller streams generally head in narrow gorges. In some cases they have not completely dissected the old plain, but flow upon its surface in shallow valleys which, lower down, give way to narrow gorges, and these in turn to the rather wide alluvial valleys near the trunk stream. The greater part of the erosion which has dissected the surface of the old plain was accomplished when the land stood somewhat higher than at present. The valleys were then much deeper and some had extensive floodplains, except perhaps the largest streams near the sea. The recent change in the altitude of the land has brought the valleys below sea-level, changing the rivers from corroding to aggrading streams. They have since silted up the estuaries which were thus formed, producing the wide alluvial plains through which they now meander.

Corresponding in some degree to the valleys incised within the old plain are eminences rising distinctly above its surface.

These are residual hills which, by reason of the harder rocks of which they are composed or their position on the divide away from the main drainage lines, were never reduced to the level of the plain. Where the plain was best developed, that is, near the sea margin on either side, these residual hills are infrequent and inconspicuous. To the southward of the San Juan, in the region lying between the Sarapiquí and the San Carlos, there is also an extensive area in which the hills are almost wholly remnants of the dissected plain, their summits in general presenting but little variation in altitude. To the northward of the San Juan the residual hills occur with increasing frequency and greater altitude, and finally merge with the mountains of northern Nicaragua. They also increase in number and height from either side of the isthmus toward its center, being most abundant along a line which crosses the San Juan valley in the vicinity of Castillo. If the old plain were reconstructed by the filling of the present valleys, it would not be continuous across the isthmus, but its eastern and western portions would be separated by an irregular line of these residual hills, the low gaps between them being slightly above the level of the plain.

The relations of these three classes of topographic forms will perhaps be made somewhat clearer by a reference to the accompanying idealized sketch and section on page 236. The surface of the peneplain is indicated by the even summits of the hills to the right. Residual hills are represented to the left, rising abruptly and distinctly above the surface of the peneplain. The profile shows a transverse section of the San Juan valley and a longitudinal section of the valley of a tributary stream. The latter is represented as rising in the residual hills to the left and flowing for some distance in the narrow gorge *a b*. From *b* to *c* the stream flows in a broad shallow valley at about the level of the peneplain. From *c* to *d* it is in a narrow gorge recently cut and still being actively deepened within the peneplain. It emerges from this gorge at *d* and thence to the margin of the main river valley at *e* it meanders through an alluvial plain continuous with the San Juan floodplain *e f*. The bottoms of the valleys which the tributary and the trunk stream occupied before the recent depression of the region is represented in the profile by the solid line between the alluvium and the underlying rock. When these valleys were formed they were considerably above sea-level and the streams had a much more rapid fall than at present, but they are now somewhat below sea-level.



Summing up the foregoing statements very briefly, it appears that the surface of the Nicaraguan depression consists of a broadly undulating plain formed by the erosion of streams flowing to the Pacific and to the Atlantic from low gaps at the divide. Above this plain are residual hills, most abundant at the axis of the depression, where the continental divide was formerly located, but increasing in height along the axis toward the north, where they merge with the mountains of northern Nicaragua, and finally, there are many valleys which have been cut in the surface of the plain by the erosion of streams after the region had been elevated to a higher altitude. The lower portions of these valleys have subsequently been drowned and silted up with the formation of broad alluvial floodplains.

During most of the time in which these topographic features were being developed the Pacific coast had an outline very different from that which it has at present. Lakes Nicaragua and Managua then had no existence, and the region which they now occupy was in part the location of streams flowing to the Pacific, in part open ocean, and in part a bay which then indented the Pacific coast and whose southern point was near the present island of Madera. The relations of the present and former coast lines are shown on the accompanying map, plate 6.

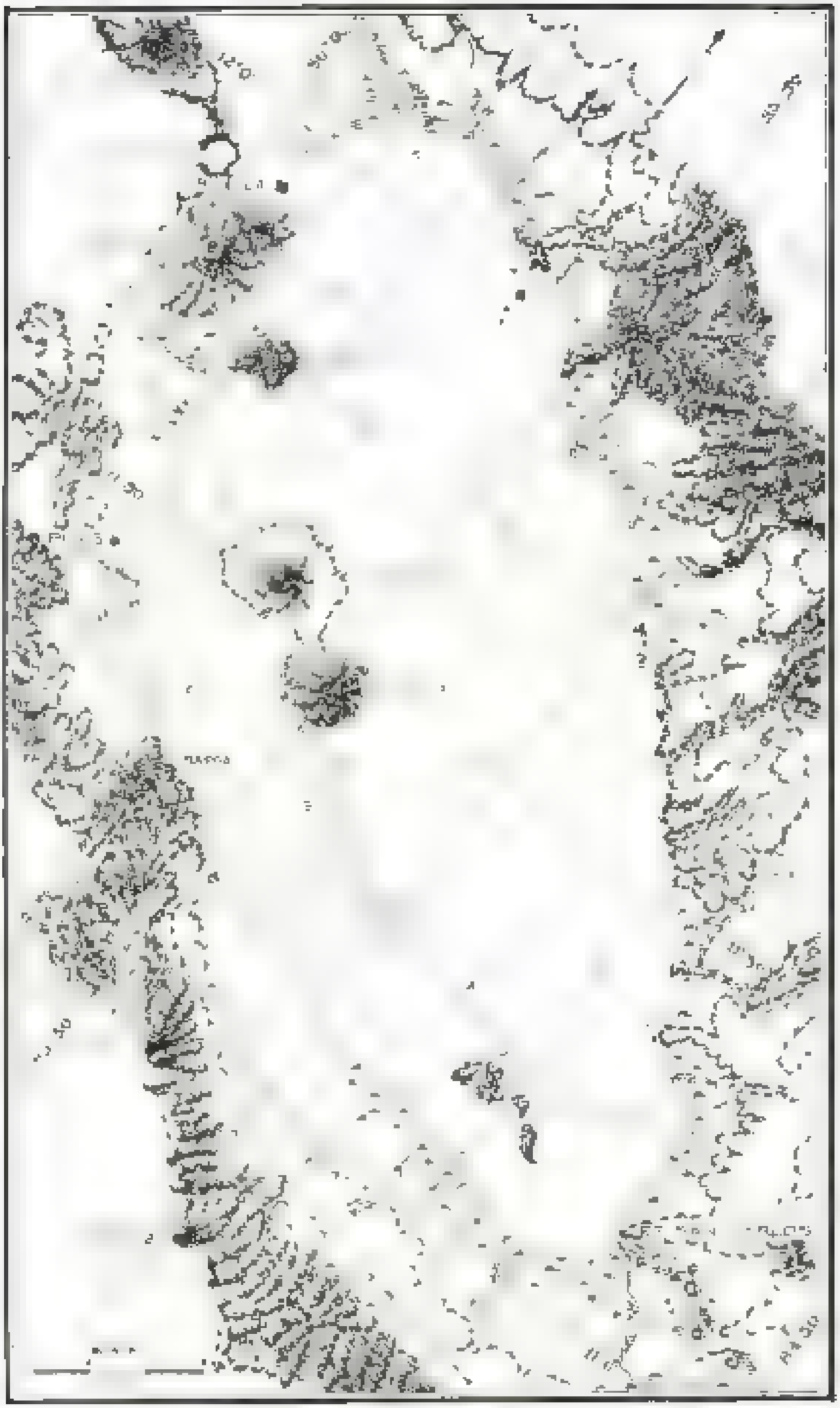
Lake Nicaragua has a regular oval outline, its longer axis extending about northwest-southeast. Its area is very nearly 3,000 square miles, and the mean elevation of its surface is about 104 feet above tide. Its shores present considerable diversity, depending chiefly on the character of the rocks which form them and the direction of the prevailing winds. The trade winds blow with great persistency throughout a large part of the year. They are deflected from their normal course by the high volcanic range of northern Costa Rica, so that instead of being northeast winds they vary from east to east-southeast. As a result of this constant wind direction the southeastern end and northeastern side of the lake rarely experience any surf, and hence those portions of the lake shore have no beach, but are bordered by swamps, with vegetation constantly encroaching upon the lake. Along the southwestern side and western end of the lake, on the other hand, there is a constant heavy surf and as a result a broad sand beach, generally backed by a wave-cut cliff. The accompanying map (page 230), based upon surveys made by the U. S. Nicaragua Canal Commission, shows the configuration of the lake basin. The most interesting features shown is the old channel, evidently a drowned river channel formed when the southern half of the lake basin was dry land. This channel marks the course of a river formed by the union of the several streams now entering the lower end of the lake with the one which occupies the upper portion of the San Juan valley. It is first detected in the vicinity of the Solentiname islands, and if it was ever excavated between this point and the mouth of the Frio this portion has subsequently been filled by sediment brought into the lower end of the lake. From the Solentiname islands for about 10 miles northwestward there is only a slight indication of the channel. Thence to the base of Madera it is continuous and distinct. The greatest depth in the lake, over 200 feet, is near the western end of this channel.

To the west of the bay, which, as shown on the map, plate 6, formerly indented the Pacific coast, was a long cape or peninsula. This now forms a part of the narrow strip of land occupied by the continental divide between Lake Nicaragua and the Pacific. This part of the Isthmus, although intimately connected with the Nicaraguan depression, is not properly a part of it. Its topography is particularly interesting in connection with the proposed canal, since it contains the lowest gap in the continental divide between the straits of Magellan and the Arctic ocean.

The manner in which this gap was developed is worthy of consideration.

Bordering the lake along its southwestern side is a very perfectly base-leveled plain from five to eight miles in width, which I have called the Rivas plain (see map, page 242). This is probably a portion of the same peneplain which forms the fundamental topographic feature of the Nicaraguan depression, and was at one time doubtless continuous with it. From the lake shore where the waves have cut a narrow terrace backed by a low cliff, the plain ascends toward the southwest at the rate of about 8 feet per mile. Its even surface is interrupted by occasional low residual knobs, which increase toward its inner margin, passing into the continuous ridges and high hills of the main continental divide. The Tola hills which border the Rivas plain on the southwest here extend to the Pacific, although further toward the northwest a narrow coastal plain is developed similar to the Rivas plain on the opposite side of the range.

The Tola hills doubtless correspond to the residual hills which rise above the peneplain of the Nicaraguan depression. They have a serrate outline, the altitude of their summits varying between 800 and 1,800 feet. While this range of hills still formed a long, narrow point of land between the *bay of Nicaragua* and the Pacific, the effect of deformations and wave erosion was such as to make the position of the divide asymmetrical. As shown on the map, it was for a time located very much nearer to the Pacific than to the head of the bay. Hence the streams which headed upon the divide and flowed in opposite directions were of very unequal length. Those flowing out to the bay must have been five or six times longer than those flowing west to the ocean. Such conditions rendered the divide unstable and the familiar process of shifting toward a position of stable equilibrium took place. A stream occupying the position of the lower portion of the Rio Grande, by reason of the advantage which it possessed in having its fall concentrated within a short distance, cut back into the divide and diverted to its own basin successive portions of the opposing stream. At the beginning of the process an eastward-flowing stream occupied the valleys of the present Tola, upper Rio Grande, Guiscoyol, and lower Las Lajas. A small tributary headed against the Pacific stream on the divide in the vicinity of La Flor. This tributary was first reversed and then the upper portion of the original stream, the present Tola, was diverted toward the southwest. The same process was continued



[illegible] the divide was pushed back to its present position at Ta-[illegible]. Streams to the northward also suffered some loss of territory. Thus upper tributaries of the Medio and Ochomogo were diverted, forming portions of the present [illegible], Mayorga, and Chococenos. The deserted river valley formerly occupied by [illegible] flowing Tola and Cascabel, and from which the beheaded Guascoyol now drinks, forms the lowest gap in the continental divide. Its summit is 154 feet above sea-level, and its ascent is so gradual from either side that accurate instrumental work is required to locate the divide. During the wet season the gap is occupied by a swamp from which the water appears to flow into both the Atlantic and Pacific.

The map (opposite 16), on which the present and former coast lines are represented, shows that a large land area has recently been added to this portion of the isthmus. The topography of this region differs totally from that of the Nicaraguan depression above described. The latter is an old land, and its surface forms are those developed by the processes of erosion and degradation. The former, on the other hand, is composed of materials recently ejected from volcanic vents, and it retains to a large extent its original constructional forms.

Extending through the center of the area in question is a line of volcanoes, all of which are geologically very recent, while some are still active. From these numerous vents, which were at first submarine, a vast amount of material has been erupted, building up broad, gently sloping plateaus from which rise more or less isolated volcanic cones. The southernmost of these volcanoes are the two peaks of Madera and Ometepe, which occupy an island in Lake Nicaragua. Toward the northwest are Zapatera, also an island, Mombacho, Masaya, Chiltepe, Momotombo, the clustered peaks forming the Marabios ridge, and finally Cosegüina, on the Gulf of Fonseca. Most of these volcanoes have erupted both molten lavas and fragmental material, the latter varying from coarse blocks of solid lava to the finest dust. It is this fragmental material which gives to these volcanoes their beautifully symmetrical forms. Those which have been recently active, as Ometepe and Momotombo, are almost perfect cones. The effects of erosion, however, are seen almost before the volcanic activity ceases, and the symmetry of the cones is quickly destroyed. The details of outline in the ash cones vary from year to year. When the loose material has been removed or solidified by erosion the summits assume the

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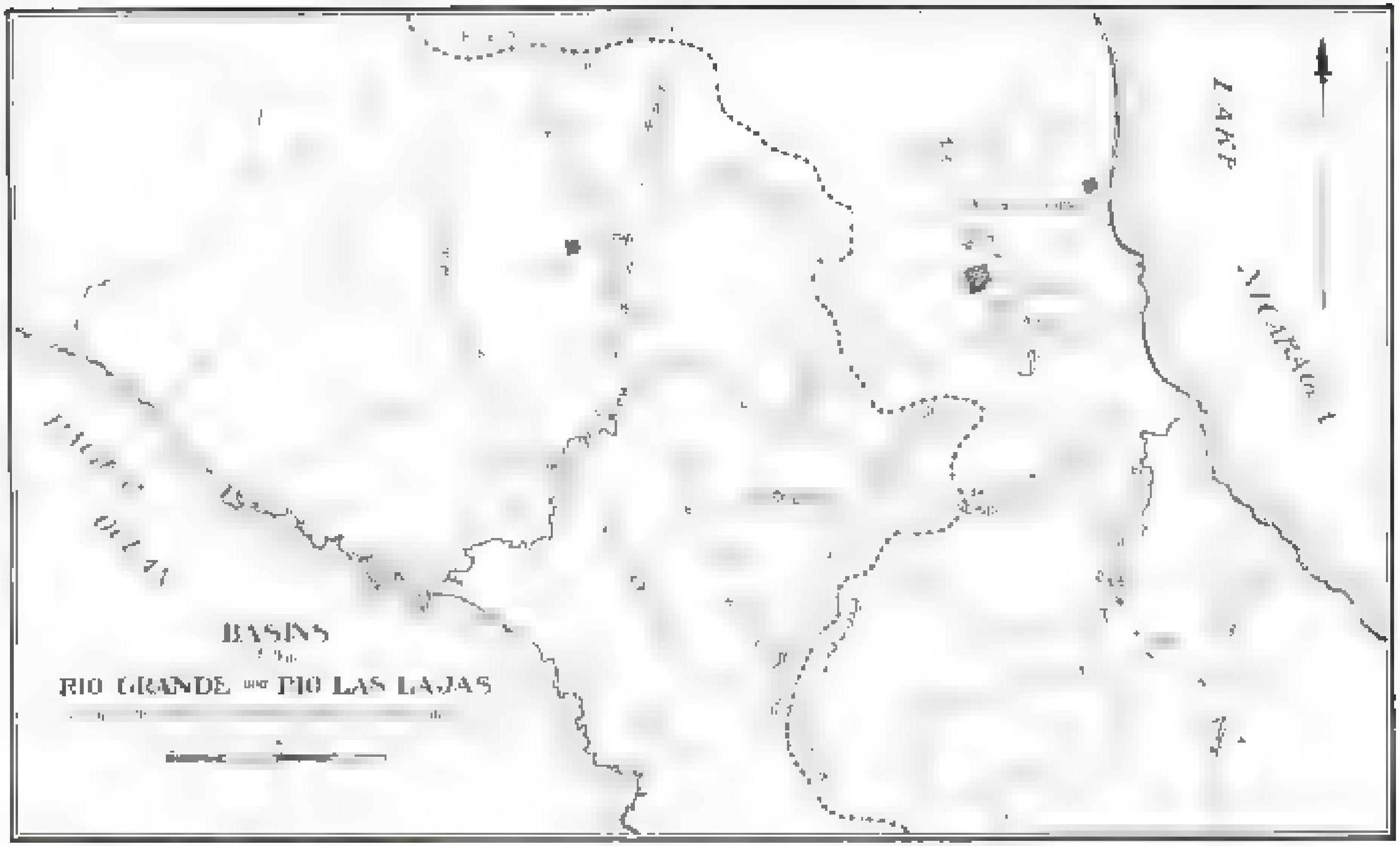

LAKE
VICTORIA
BASINS
OF THE
RIO GRANDE AND RIO LAS LAJAS

...general grade or elevation. The streams were thereby ... and ... which they had previously formed. ... Here was a repetition of the process of ... which had ... for a long time. The second glacial period ... has continued ... to the present time. It was marked ... by two nearly parallel lines of ... One of these lines gave rise to the Green Bay ... and the other to the ... region ... The ... of the Lake Michigan ... They ... and nearly parallel with the ... coast, ... to the ... but the southern end of the ... with ... an ... Vast ... of ... and ... were ... from these ... and ... Wisconsin ... but ... from the ... the ... was ... than the ... in the ... The ... of the ... was gradually ... and the ... Lake ... Chicago ... and ... Water ... but ... after the ... and ... began, ... to ...

... ice ... so much ... that ... formed a ... but ... a ... to the ... They ... to the ... Bay, ... is ... by the ... parts of the ... but ... between ... Lakes. ... the ... first ... and ... to ... they ... considerably ... those ... The ... forming ... however, ... land ... and ... quickly ... the ... rock, ... it ... been ... to the ...

The latest ... in its ... history ... the ... ... of the ... to ... of ... by ... of ... Bay, ... with ... This ... extends ... to the ... where ... with ... and ... by a ... ...

A few of these Pacific streams have not yet completely filled their old valleys with sediment, and the upper portion of one branch of the San Juan—the Sarapiqui—flows northward to the Caribbean, but it may hardly be said to occupy a valley, but has entered the outer edge of a broad delta plain.

The San Juan river and its tributaries present an intimate relationship to the canal scheme that deserves somewhat more detailed account. From any point of view, either with reference to the history of the development of the canal route or to its present importance, the San Juan valley is entitled to first consideration. Starting from a point where the river leaves Lake Nicaragua, the first extends to the head of the Tipitapa, becomes from the head of the Tipitapa to the mouth of the San Carlos river, and then from the mouth of the San Carlos to the sea.

The upper part of the river has a moderate current and a considerable depth. Its banks are low and swampy, except where it passes over the flow of crystalline rocks, which it traverses in a series of rapids and falls known as the Castillo rapids. Below these rapids the lake formerly extended down to and beyond the present mouth of the San Juan, but a large amount of sediment from the waters of the San Juan has now reclaimed this part of the lake, and it is now generally recognized that lakes are ephemeral features of the earth's surface, being filled up by the deposition of sediment from their tributaries. In this case, however, the first of these processes has been greatly retarded. The area of the lake is being encroached upon by the waters which come from the south, which are poor in sediment, but by the tributaries which enter the lower part of the San Juan. The present river of San Juan [illegible] the point of the peninsula which forms the [illegible] of the lake. The [illegible] tributaries which enter the lake, as it has [illegible] toward the northern edge of the old lake bed by the upper tributaries from the south. The natural flow of the river would be a matter of great concern, but it is known that [illegible] constructed on the proposed [illegible] of the canal that [illegible]

rapids has only a moderate current. Below the entrance of the San Carlos it is usually broad, with shallow water and shifting sandy bed, and has a uniformly strong current. Its slope is nearly a foot to the mile in this section. The Sarapiqui is similar to the San Carlos, although somewhat smaller. Both of these streams have their sources on the slopes of the Costa Rican mountains to the south. The recent volcanic eruptions of this region have furnished an abundant supply of unconsolidated sand to these streams and they are heavily loaded with this material. Below the entrance of the San Carlos the floodplain [illegible] adjacent to the San Juan has [illegible] than the floodplains of its northern tributaries [illegible] the latter are ponded in their upper courses and many lagoons are thus formed. From the mouth of the San Carlos eastward the San Juan occupies the northern margin of its valley. This is doubtless due to the more abundant supply of sediment furnished by the southern tributaries and also to the northward drift of the littoral current in the Caribbean sea. As the river extended its course eastward by the filling of the estuary, and later by the formation of the deltaplain, it was continually crowded to the northward by the direction of the sand drift along the coast. This tendency became more pronounced the farther out the delta was built, and the sharp northward bend of the lower San Juan is its direct consequence.

As the river channel was carried northward the northern portion of the valley would be filled first and to a higher level than the southern portion. The river would thus at times find itself in a position of unstable equilibrium, and would seek a new channel on the lower part of the deltaplain to the southward. Thus it is probable that the river originally occupied the present channel of the San Juanillo. When this position became unstable it gradually deserted its northern channel for the present position of the lower San Juan. Subsequently the latter became unstable, and a more favorable course to the sea was found still farther south. The recent channel of the Colorado was thus developed at the expense of the lower San Juan. This process is still going on, and the relative amounts of water carried by the two channels has very materially changed within a generation. Unless artificially modified, the lower San Juan will continue to dwindle, and probably all the water will find its way to the sea by the Colorado or by some more favorably located channel still farther south.

NICARAGUA AND THE NICARAGUAN ROUTES

By A. P. Low,

Photographer, U. S. Interoceanic Survey

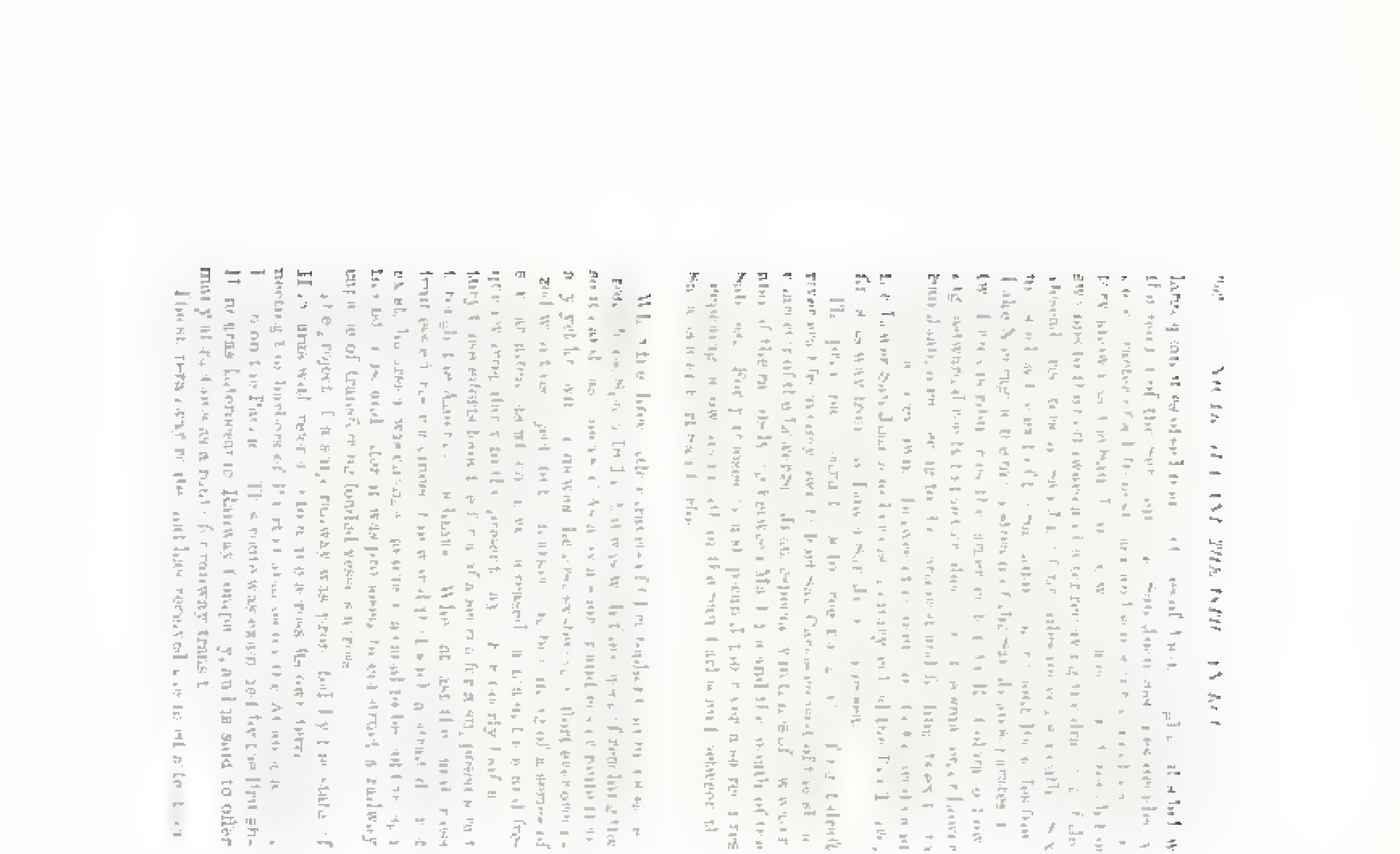
The state of Nicaragua is by far the largest of the Central American republics. It lies entirely within the tropical zone, and although it will say have ranked as about the fourth state in the order of size, and as the smallest in point of population. It is bounded on the east by the Caribbean Sea, on the west by the Pacific Ocean, and lies between the equal lines of Honduras and Costa Rica to the north and south. The northern part is largely occupied by mountains and plateaux, but the southern portion is a low-lying plain. A little northwest of the centre of the state, but following a southeasterly course, nearly parallel to the Pacific coast, almost to the south line of Nicaragua, it is traversed by the Nicaragua lake. The eastern part of the state is drained by the San Juan river. The western part is mostly forms the Pacific coast, and is peculiar in the low plain and the narrow strip of land at its east.

The east coast for a distance of 200 miles inland is mostly of a swampy nature. It abounds in lagoons, as the coast at this point has a very slight gradient, but it is these same lagoons that furnish the natural ingredients for the making of the valuable

In the matter of rainfall in Nicaragua the records are very meagre. There is a record of 10 years at Rivas, which [illegible] January, 1886, and is still continued. This record has been voluntarily kept by Dr Earl Flint, an American resident of Rivas. A rainfall record was also kept at Managua from January 1886, to December, 1887, by Mr A. Lainé. The observations were taken and transformed to [illegible] and have been compared with other stations, such results are [illegible] the rainfall at [illegible] stations from 1887 to 1889 inclusive. From 1889 were used in connection with [illegible] Nicaragua Canal Survey, 1887-8, by Mr A. P. Low, also in 1893 and 1894 by the National Institute at Granada. At Bluefields observations were made by Hon W. H. Jackson and others from September 1887 throughout 1894 and 1895 until a portion of 1896. The Nicaragua Canal Company kept a record of rainfall at

T

at gages and receives several tributaries of importance to the Sacramento, which is here [illegible] Deschutes [illegible] Fort Sam Custer. About [illegible] below the mouth of the Salmon are the first rapids called Tumwater Rapids. These rapids are caused by lava [illegible] probably brought into the river by the Salmon in former times, but [illegible]



[illegible]

locks close together near the Pacific coast, and the uncertainty of a sufficient water supply for the summit level.

The Truando-Atrato route is a modification of the Napipi-Atrato route, the project being to leave the Atrato river about 30 miles from its mouth and then to cut a sea-level canal through a tunnel under the continental divide at the Pacific, the flow of the Atrato river being diverted into the Pacific ocean. The length of the cut from the Atrato to the Pacific would be [illegible] miles. The cost of the work has been variously estimated from $135,000,000 to $150,000,000. The chief difficulties of this route are the considerable tunnel excavation and the control of the flood waters of the Atrato river.

San Blas Route.—This route lies between the gulf of San Blas on the Caribbean sea and the mouth of the Bayano river on the Pacific. It is the narrowest part of the entire isthmus, being only 30 miles from ocean to ocean. It is proposed that the level of the water in this canal be that of ordinary high tide in the Pacific ocean. The tides in the Caribbean sea being inconsiderable, no provision need be made to accommodate them. On the Pacific coast the tides are from 10 to 20 feet, and a lock would need to be provided for maintaining the canal at any desired level. At high tide the lock can be left open, while at low tide there would be a considerable [illegible] by means of the lock. This route requires the construction of a tunnel seven miles long, which is proposed to be 80 feet wide at the surface of the water and 160 feet high from the canal bottom. Much [illegible] in regard to the practicability and cost of the [illegible] no tunnel of such length and dimensions has yet been attempted, and it is claimed that the [illegible] in the tunnel, the constant shower of chilled water from its roofs and sides, and its damp, vitiated condition would rapidly [illegible] the workmen, who would be unable to carry on successfully [illegible] other conditions to health which would [illegible]. The long tunnel required, with the accompanying uncertainty of cost and completion, is the chief objection to the San Blas route, though unquestionably this route has obtained a higher degree of public favor than any other excepting the Panama and Nicaragua routes.

Panama Route.—This route lies between Colon, or Aspinwall, on the coast of the Caribbean, and Panama, on the bay of Panama. The existence of fairly good harbors at each end is one of the reasons for the selection of this route, and in 1850 a railroad was

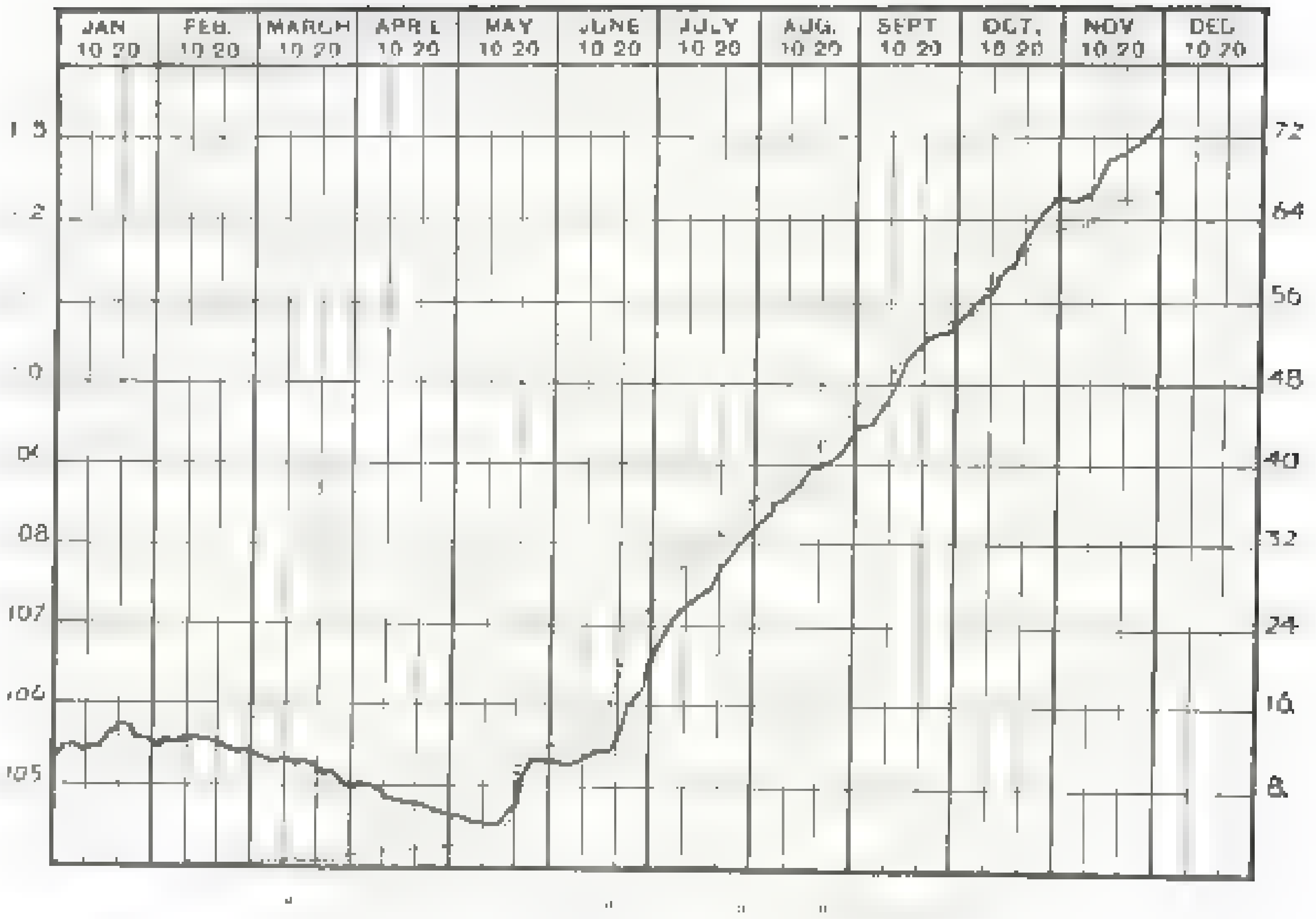
the east and Brito Bahia on the west. The total length of his proposed line was 194.4 miles, and the cost was estimated at $31,538,000. This included the cost of an artificial harbor at Brito, but at that time there was a good harbor at Greytown. The object of this survey was primarily to establish a means of communication with California to accommodate the heavy traffic induced by the discovery of gold.

President Grant took a deep interest in the canal problem, and in 1872 appointed a commission consisting of General A. A. Humphreys, Chief of Engineers, C. P. Patterson, Superintendent of the Coast Survey, and Commodore Daniel Ammen of the U. S. Navy, to examine the information at hand and determine the most feasible route for an interoceanic canal. The routes considered were the Tehuantepec, Nicaragua, Panama, and Atrato-Napipi. The commission unanimously reported in favor of Nicaragua, and this has ever since been regarded as the favorite canal route from the American point of view.

In 1873 an expedition was fitted out by the United States Government for the confirmation and continuation of the Childs survey. It was placed under the charge of Commander E. P. Lull, U. S. N., who surveyed the route with reference to the construction of a canal 26 feet deep. He confirmed the surveys of the [illegible], but, fearing difficulty with the waters of the upper Rio Grande, he recommended that the canal leave Lake Nicaragua by way of the Medio instead of Las Lajas. This was [illegible] by a mile and a half, and avoided the Rio Grande, but in[illegible] feet deeper cut through [illegible]. The western [illegible] from the Pacific at Brito [illegible]

of Lake Nicaragua and of the San Juan river. It was thought that the river could be improved at the rapids by means of locks and that by these means only the [illegible] could be converted into a canal to a point near the mouth of the San Carlos. Here it was proposed to construct a dam, and the canal was to leave the river and follow near it until the swamp region was reached, which [illegible] the San Juanillo to [illegible] Greytown. Seven locks were proposed west of Lake Nicaragua, and [illegible] on the east side. The estimated [illegible] including [illegible] of Greytown harbor [illegible] was in all $[illegible].

Associated with Commander Lull in this survey was Mr. A. G. Menocal, a civil engineer of the navy, who has since become famous as the chief engineer of the Maritime Canal Company.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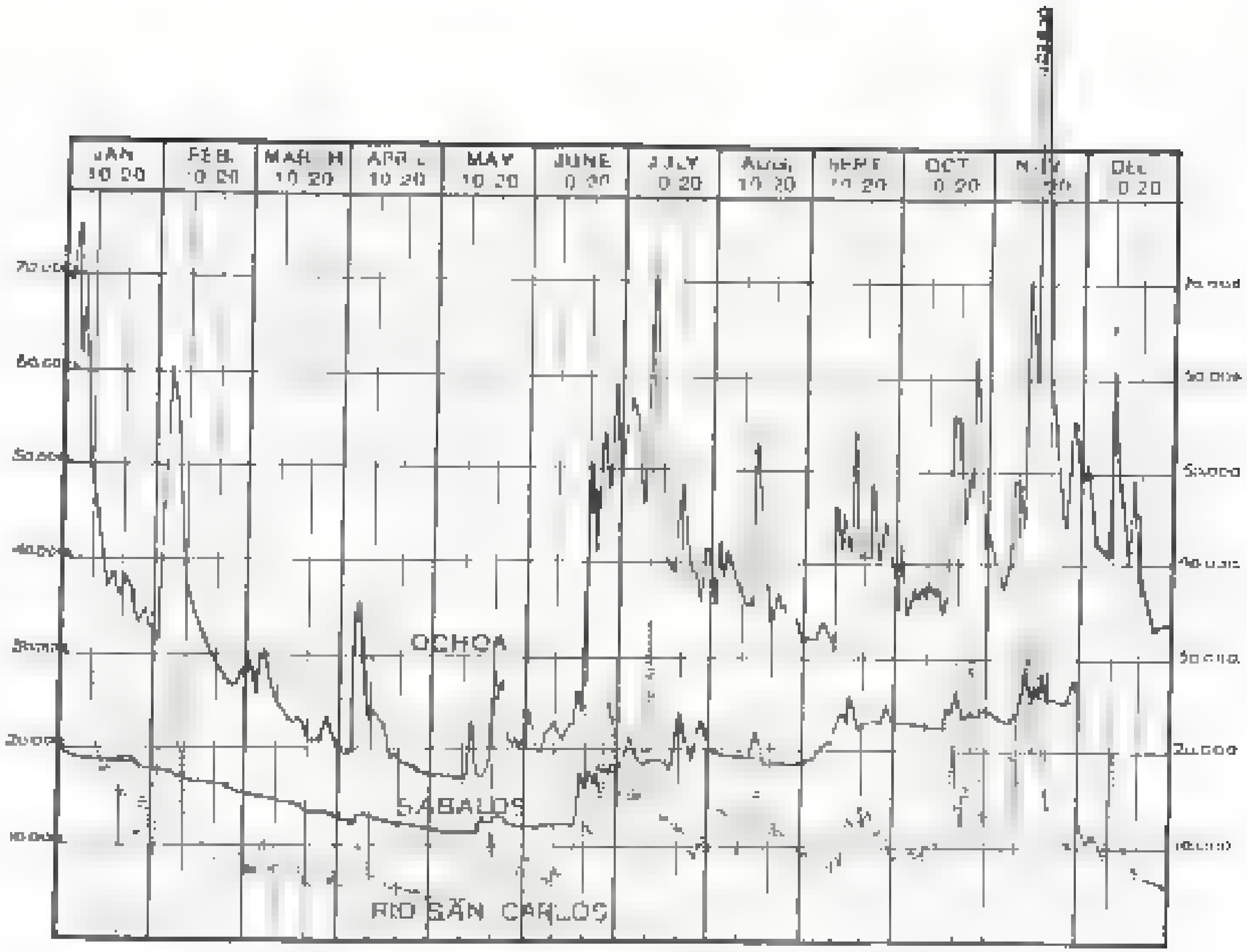
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RIO SAN CARLOS

that amount [illegible] the summit level. [illegible] 50 feet would be necessary to secure a [illegible] depth of [illegible] feet at the beginning of every dry season. There are very strong [illegible], however, [illegible] years [illegible] in which the evaporation exceeds the rainfall by two feet, so that it would [illegible] against the exceptionally dry years [illegible] 34 feet [illegible] the beginning of the dry [illegible] secure a [illegible] depth [illegible].

Only two streams carried any considerable quantity of water into the lake last April. These were the Frio, which enters at Fort San Carlos, and the Zapote, entering in at the extreme south end. A few others are [illegible] the year round, but most of them [illegible]. During the dry season, [illegible] estimates from [illegible] to 25 feet deep. Aquatic vegetation grows in great profusion in these streams, choking the channels, unless a passage for navigation is kept open by canoes. This vegetation is not rooted to the soil, but floats freely and shows no disposition to flow out toward the lake. The water is dark-colored, and almost stagnant. When the rainy season sets in in earnest, however, these winding deep channels are filled with a rushing current so swift that it is very difficult to paddle a canoe against it. The floating vegetation is carried out in great quantities, forming floating islands several hundred feet across. As the current of the stream often extends far out into the lake, the floating vegetation forms a large crescent around the mouth, and in some cases constitutes quite an annoyance to navigation. Some of these islands find their way to Fort San Carlos, and pass down the San Juan river. The inflow to the lake is sometimes as great as [illegible] cubic feet per second, and to prevent injurious submergence of adjoining property it is necessary to provide a spillway of large capacity, and to control the discharge so as to waste the surplus and yet to store the large amount of water necessary to provide for the evaporation from this immense lake surface.

As illustrating the problems solved by the survey, the extreme flood discharge of the San Juan at Ochoa was estimated by the company at 66,000 cubic feet per second. A discharge of about [illegible] cubic feet per second has been already observed, and a study of the flood marks in connection with the observations at the same point shows that the maximum discharge cannot be less than 200,000 cubic feet per second, or more than three times the estimated maximum. The San Carlos and Sarapiqui rivers

THE WELLMAN POLAR EXPEDITION

THE COAST AND GEODETIC SURVEY: ITS PRESENT WORK

season is the first in which several classes of work are carried on simultaneously and systematically on the 98th meridian.

A Coast Pilot party has been organized for the purpose of bringing the present publications up to date by additions and corrections. The information sought will be in the following lines:

I. General description of the coast.
II. Detailed directions for avoiding dangers.
III. General sailing directions.
IV. Geographical positions of lighthouses and beacons.
V. Practical information in regard to fog signals, tides, variations of the compass, etc.
VI. Views of the coast and principal harbors.

Additional work has been planned by the Coast and Geodetic Survey, but the parties have not yet been assigned nor selected. A line of precise levels is proposed from the Great Lakes southward, crossing and checking our work on the 39th parallel and continuing to Tennessee, there to connect with lines from the seaboard by the Geological Survey, thence onward to the work of the U. S. Engineers in Mississippi, and finally connecting with our own lines brought north from the Gulf. Such a line would form a connecting link between the work of the three great government organizations.

E. D. Preston.

EXPLORATIONS IN ALASKA

During the past winter the maps and reports of the exploring parties that visited Alaska last year have considerably increased general knowledge of that country, with special reference to determining in what lines future exploration may be most advantageously carried on this summer. The largest unexplored area lying south of the Yukon and west of the Alaskan boundary is that about the headwaters of the Kuskokwim, and including the towering peaks of Mt. McKinley and its neighbors. Is an area of special interest toward which future exploration may be reasonably directed. But careful study and knowledge of the conditions of access show that except by means not adequate returns could be expected from an expedition to that region this year. The experience of last season, when the exploring party could advance against the current of the streams but from one to three miles a day, and hence consumed all the time in getting there, has proved that the streams must be ascended while they are still

The second party in charge of Mr F. C. Schrader, geologist, and Mr T. G. Gerdine, topographer, will proceed by the now well established route down the Yukon to Fort Yukon, or some point in that vicinity whence a convenient route northward can be found. The equipment will be the same as that used last summer, consisting of [illegible] outfit that can be easily packed and carried. Beyond this starting point the route is left to the discretion of the chief of the party, but his general instructions are to penetrate the [illegible] of the upper Koyukuk as far as possible. The main purpose of this expedition is necessarily geographic, but geologic information will be gathered so far as practicable. It is expected that valuable information will be gathered to determine future plans for the exploration of the region between Bering sea and Arctic ocean. This party will continue its work until forced to retreat [illegible] of winter and will then float down on the swift current of the Koyukuk river. Neither party will winter in Alaska. Although the advantages of such a course have been recognized, careful consideration shows that it is inexpedient with present knowledge and available means.

METEOROLOGY IN THE PHILIPPINES

In view of [illegible] through the [illegible] by the director of the Manila Central observatory, of action taken by the United States government in suspending all telegraphic typhoon warnings made [illegible] Manila observatory for points outside of the Philippines, [illegible] proper to present for the information of all persons interested [illegible] a statement of the facts and circumstances which led up to the action taken by the United States authorities.

In a communication dated November 5, 1898, Dr W. Doberck, Director of the Hongkong observatory, forwarded to the Chief of the United States Weather Bureau [illegible] that the Manila observatory was [illegible] sensational typhoon warnings [illegible] the [illegible] newspapers. [illegible] that this [illegible] was against [illegible] and [illegible] for the guidance of [illegible] meteorological [illegible] authority in one country [illegible] another country, [illegible] and [illegible] that the American government of the Philippines [illegible] which interfered [illegible] the work of the Hongkong observatory.

Acting upon the recommendation made by Dr. Doberck, approved by the Chief of the United States Weather Bureau, the Secretary of Agriculture requested the Secretary of War to provide for discontinuing telegraphic typhoon warnings from the Manila observatory to points outside of the Philippine islands. The position taken by the United States authorities was that the Manila observatory was improperly interfering with the British observatory by sending warnings into the territory covered by the observatory at Hongkong, and that warnings of this character should not be sent except upon the request of the British government. They held that as Director of the British meteorological observatory, having jurisdiction over these technical matters for the British government in China, Dr. Doberck would not be justified in sending weather forecasts to Manila, and that such action on his part would, with propriety, be resented by the officials of the Manila observatory. In this position they were strengthened by the relations which have for many years existed between the prominent meteorological services of the world. The United States and Canadian meteorological services never presume to issue forecasts or storm warnings for any part of the territory under the sovereignty of the other, notwithstanding that they have in their possession daily meteorological observations from observatories both in the United States and Canada.

The British government has a chief observatory at Hongkong and possesses a chain of meteorological observatories extending [illegible] miles northeastward and 800 to 1,000 miles southward, and in addition receives reports from Bolinao, on the island of Luzon. In fact, the director at Hongkong possesses a system of observations which is necessary to the issue of forecasts that are worthy the serious attention of mariners. The practice of the Manila observatory of issuing storm warnings for Hongkong and the China coast was not only contrary to international usage, but was not justified by the possession of superior facilities for making the forecasts. The relative accuracy or value of the warnings issued by the Hongkong and Manila observatories and the comparative scientific attainments of the directors of these observatories did not enter into the question and had no bearing upon the subject. Dr. Doberck has by years of well-directed work and study established an excellent service and gained an enviable standing as a meteorologist, and is unquestionably entitled to the consideration and courtesy which usage has accorded to directors of meteorological services.

THE MISSION OF THE "LIANA"

GEOGRAPHIC LITERATURE

[illegible] descriptive terms [illegible] [illegible] W. J. M.

GEOGRAPHIC MISCELLANEA

[illegible]

[illegible]

[illegible]

[illegible] [illegible] "The Alaskan Boundary," by Marcus Baker, secretary of the U. S. Board on Geographic Names.

[illegible] the Weather Bureau [illegible] forecasts [illegible] for all states east of the Rocky Mountains, were regularly issued from Washington each night during April, [illegible].

[illegible]

Reports from Vancouver, B. C., announce the ascent for the first time of Mt. [illegible] Malayan [illegible] from any known race.

The next meeting of the International Meteorological Committee will be held in St. Petersburg August [illegible]. [illegible] Moore, Chief of the Weather Bureau, is the representative of the United States. Among the other members [illegible] Mascart, France; R. H. Scott, [illegible] Britain; W. [illegible], Germany, and M. Rykatcheff, Russia.

[illegible] Los Angeles, [illegible] an accurate [illegible]

The [illegible] geologists [illegible] excursion of sixty days to study the [illegible] the [illegible]. The professors of the various

The Johns Hopkins University has sent a medical expedition to Manila for the purpose of studying the climatic and tropical diseases as they may be observed in the Philippine Islands. Two of the professors of the Johns Hopkins Medical School, Dr. Simon Flexner and Dr. L. F. Barker, both of them highly trained pathologists of wide professional experience, volunteered for this service. They go well equipped with the best apparatus for pathological and bacteriological research. They carry letters of introduction from officers of the government at Washington. Two advanced students of the medical school, Joseph M. Flint, of Chicago, and Frederick P. Gay, of Boston, are members of the party, and Mr. J. W. Garrett, of Baltimore, is also a member. The expenses are defrayed by generous contributions from these and other gentlemen. The party sailed from Vancouver for Manila by way of Yokohama and Hongkong. Several days were passed in Japan, where Professor Kitasato, of Tokyo, gave them special opportunities for observing certain cases of disease in the hospitals of that city. Upon reaching Manila, Drs. Flexner and Barker commenced work at once, their inquiries being facilitated by the coöperation of Colonel Woodhull, M. D., U. S. A. In Manila there are two large army hospitals, the first and second reserve hospitals. [illegible] Dr. [illegible], who accompanies Prof. Dean C. Worcester in his travels through the islands, [illegible] hospital at Cavite, and a convalescent hospital at Corregidor.

In "The Race for the North Pole," which appears in the June Munsey, Gen. A. W. Greely reviews the work of the three explorers, Peary and Wellman, Americans, and Sverdrup, Norwegian, who are trying to reach the Pole. Of the three explorers, Peary and Sverdrup have followed what is known as the American or Smith Sound route by the channels leading from Baffin Bay northward along the west coast of Greenland to the polar ocean. As to the probability of their success, General Greely states: "There are two phases of the question: first, whether the waterways to the Windward or the Fram can round the northwestern point of Greenland and [illegible] St. George's fiord, and second, the possibility of the Fram circumnavigating Greenland, and that of the Peary or Sverdrup parties reaching the Pole by sledge journeys." Even should the coming season permit either ship to reach St. George's fiord, of which progress from past history there is little probability, it would never be able to leave the fiord. From St. George's fiord the explorers would [illegible] Cape Washington, the most northerly known land, 83° 24', whence they would have a journey of 460 miles each way over the ice pack, or a distance three times greater than that covered by Nansen after leaving his ship. General Greely believes that Wellman, who has chosen the Franz Josef Land route, has the most difficult task before him. "The difficulties of ice travel are very much greater in the case of Wellman than of either Peary or Sverdrup. The distance over the frozen sea from the northernmost point of Franz Josef Land to the Pole and back again cannot be much less than 1,000 miles, and the reader who has studied the narratives of Markham or Nansen can conceive that such a journey is within human power in a single season."

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